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DETERGENTS AS THEY AFFECT THE SEWAGE TREATMENT PLANT

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Cincinnati, Ohio

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By

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Background

Detergents are substances that have a cleaning action due to a combination of properties that include lowering surface tension and wetting, emulsification, and dispersive action. Although soap is included in the definition, this discussion is restricted to nonsoap detergents or syndets. Analytical syndet determinations referred to are by the methylene-blue extraction method and are expressed as anionic surface active agents in parts per million unless otherwise noted. Mixed liquor solids referred to are mixed liquor suspended solids in parts per million.

The table below shows a typical household synthetic detergent analysis.

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Table 1

Typical Packaged Household Detergent

Component	Quantity Percent
Surfactant	
Alkyl Aryl Sulfonate	30
Builders	
Tripolyphosphate	28
Sodium Silicate	6
Sodium Carboxymethyl Cellulose	1
Sodium Sulfate, Sodium Chloride and Moisture	35

Builders and other materials are used to enhance the properties of the total product or to increase its volume. The organic surface active agent (surfactant), which may comprise only 20-40 percent of the total product, is the portion which is of most concern to sewage plant operators. Of the several types of surface active agents, the anionic is the most widely used and the only type normally determined. Nonionic surface active agents, however, are increasing in popularity.

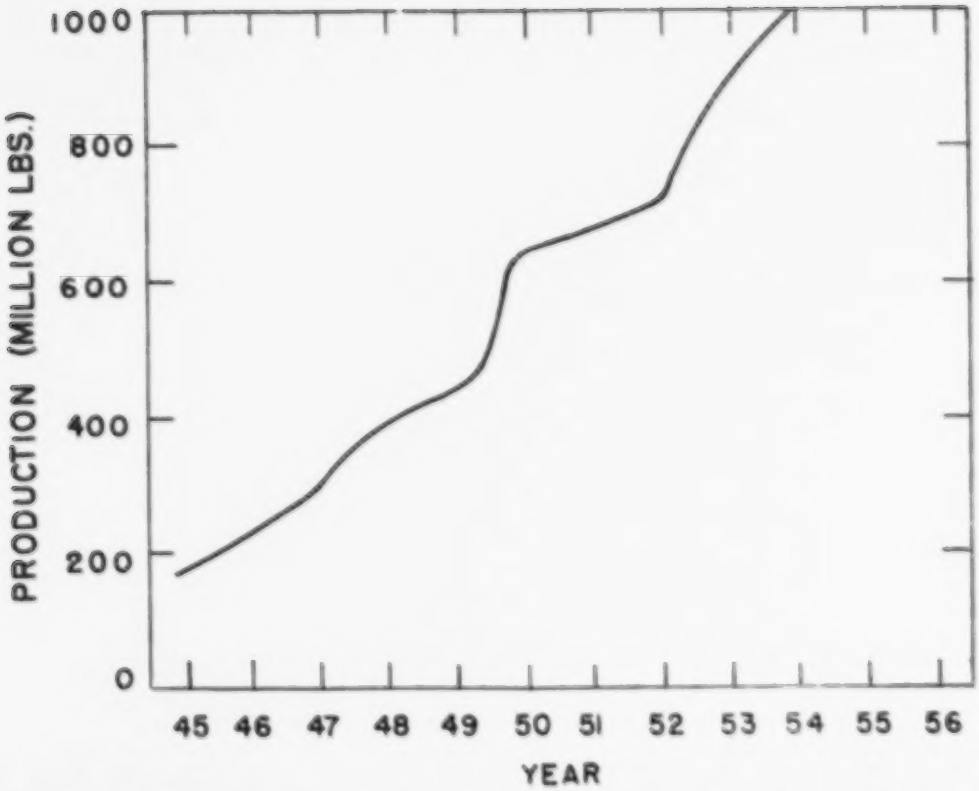
The characteristics in synthetic detergents that are desirable for household cleaning are unfortunately the reverse in the sewage treatment plant. These characteristics include the ability to disperse rather than collect or settle solids and the ability to form suds.

Although synthetic detergents have been known to industry for as much as 40 years, it was only in the post World War II period that they have come into widespread household use. Figure 1 shows annual synthetic detergent sales. It is interesting to note the sharp increase in 1950 and the current trend toward increase.

Consumption of synthetic detergents for household use varies considerably from area to area with water quality, probably because soaps are more satisfactory in some areas, particularly in those of low water-hardness. It can thus be seen that sewage treatment problems associated with synthetic detergents vary from city to city. It is difficult therefore to cite a "typical" syndet concentration for sewage. Ross (1) has stated that calculations have been made which show that, "... assuming all the detergents used in the home went on unchanged to the sewer, then domestic sewage would contain an average 50 parts per million of total detergents or up to 10 parts per million of surface active agent." Data obtained from Windsor Village, Indiana for January 1955 indicated a mean syndet concentration of 10.9 parts per million. At Fort Wayne, Indiana mean syndet concentrations for 1954 were 3.5 parts per million; for 1955, 4.4 parts per million; for 1956, 9.8 parts per million.

Frothing

The most commonly reported problem attributed to synthetic detergents is frothing, probably because it is the most apparent. It should be pointed out that evidence connecting frothing to synthetic



TOTAL U.S. PRODUCTION OF SURFACE ACTIVE AGENTS

(100% ACTIVE BASIS)

FIG. 1

detergents is largely circumstantial. This evidence includes the several instances where frothing has occurred immediately following the introduction of synthetic detergents into an area, the general occurrence of frothing throughout the country associated with the beginning of their widespread household use, and knowledge of their froth producing properties. Because of the difficulty and doubtful reliability of analytical methods applied to synthetic detergents in sewage, more concrete information has been difficult to obtain.

Frothing was first reported in the literature and attributed to synthetic detergents at a mechanical aeration activated sludge plant at Mount Penn, Pennsylvania (2). Frothing has subsequently been reported and attributed to synthetic detergents at plants throughout the country including Bartlesville, Oklahoma (3); Batavia, Illinois (4); Rockville, Md.; Triangle, Va. (5); Benton Harbor, Mich. (6); Baltimore; New York; Los Angeles; and Philadelphia (7). Froth has also been reported by a number of mid-western plants with which the writer is familiar, and Figures 2 and 3 illustrate frothing at two of these plants. British experience is similar (8). A questionnaire was sent to 38 (most) large activated sludge plants in England. All but one reported frothing and 23 described the condition as serious. Thirty-three of 44 biological filter plants questioned reported frothing ranging in extent from "slight" to a depth of four to six feet.

The Mount Penn incident occurred in 194[illegible] following distribution of free samples of a nonionic synthetic detergent (5). The diffused air

Froth on aeration tanks at
Fort Wayne, Ind.
Figure 2

Frothing at Findlay Ohio
Figure 3

5-C

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plant at Motherwell, England reported the first appearance of froth in September 1952 following introduction of Tide into the district (9). Sewage treatment plants in the mid-west report difficulty as having started in 1949 or 1950. Fort Wayne, Indiana, Findlay and Celina, Ohio, and other plants reporting this experience have had on occasion ten to twelve feet of froth on the aeration tanks. It might also be noted that plants experiencing the most difficulty at the present time state that their problem is increasing.

Frothing may occur in various of the component parts of a sewage treatment plant. It is commonly associated, in activated sludge plants, with the aeration tanks. In such plants, the effluent end of the aeration tank is generally considered to be the point of severest problem. However, in a tapered aeration plant at Columbus, Ohio, frothing is most severe at the point (in the tank) of highest air application. It has also been reported that Saran-wrapped diffuser tubes present worse frothing problems than carborundum tubes. This condition is particularly noticeable at Findlay where both types of tubes are installed in parallel units. It has been suggested that the intensified frothing may be attributable to a smaller bubble size. Other parts of plants affected by frothing include the effluent channels and secondary sedimentation tanks. At Celina, frothing occurs in the return sludge wells.

The general conditions commonly associated with frothing include periods of low flow, long aeration-tank retention time, high air-application rate per unit volume, low organic loadings, moderate (not cold) weather,

and in the case of combined sewer systems a high proportion of storm water in the system. Frothing is consequently commonly reported to be worse in the morning, on week ends, and in the summer or fall. Rain and also bright sunlight are reportedly a deterrent to frothing.

The concentration of syndet reportedly associated with frothing has varied considerably from case to case. Wells and Sherer (10), in plant scale studies at San Antonio, found no frothing at mixed liquor solids concentrations of 1,400 parts per million. Tide was added to one aeration tank pass in concentrations of 12 to 250 parts per million of total product, with mixed liquor solids ranging from 2,700 parts per million to 3,900 parts per million, without causing frothing. In one test 90 parts per million of Tide was added to a tank with mixed liquor concentration at 950 parts per million without causing serious frothing. Gowdy (11) experimented with the addition of household detergents to a small mechanical aeration plant at Bryan, Ohio. The detergent was added in the concentration of 100 parts per million total product based on influent flow. With a mixed liquor concentration of 800 parts per million, no frothing occurred in the aerator and only minor frothing in the effluent channel. When mixed liquor concentration was reduced to 200 parts per million frothing occurred in the effluent channel but disappeared when solids were brought up to 800 parts per million.

At Benton Harbor, Michigan Russell (6) reports that froth was a problem when syndet concentration in the raw sewage was only 8.0 parts per million and suspended solids were varied from 1,000 to 3,500 parts

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per million, dissolved oxygen from a trace to 3.0 parts per million, and return sludge ratio from 25 to 40 percent. At Fort Wayne, very heavy frothing occurred in June of 1954 with raw sewage syndet concentrations ranging from only 2.3 to 3.8 parts per million, mixed liquor suspended solids from 2,000 to 2,800 parts per million, and cubic feet of air applied per gallon of mixed liquor from .68 to .84. In August 1956 heavy frothing also occurred at Fort Wayne with syndet concentrations ranging from 4.0 to 9.0 parts per million in the raw sewage, mixed liquor solids from 2,200 to 2,700 parts per million, and cubic feet of air applied per gallon of mixed liquor from .52 to .70. On March 11, 1957 considerable frothing occurred at Findlay with a syndet concentration of only 4.6 parts per million and with mixed liquor solids at 2,330 and a sludge index of 109.

Some instances of frothing have been reported without the presence of synthetic detergents. Walker (12) noted that a frothing phase was almost universal in starting mechanical aeration plants until mixed liquor solids were brought to operating level. Martin (13) cites frothing experiences at San Francisco in 1932 and at New York in 1941 before appreciable amounts of synthetic detergents were in use, when mixed liquor suspended solids were at a low concentration. The writer has seen and heard references dating back many years to observations of moderate frothing in diffused air plants in the initial stages of operation until solids were brought to proper operating level. These cases, however, were generally not of the magnitude of problems reported since 1947.

Martin offers the plausible explanation that, "... it is probable that in any secondary treatment process there are always surface active substances being produced as a result of biological degradation by enzymes or bacteria. These substances, when free and available in sufficient concentration, cause frothing. These higher levels of naturally occurring surfactants may be established when they are produced either at a more rapid rate than that at which they are being adsorbed, or when there is not sufficient surface area afforded by the solids present for their adsorption." It seems logical, therefore, that when synthetic surfactants in the form of detergents are added in amounts exceeding the adsorptive capacity of the system, frothing occurs even where it did not formerly occur. Rohlich (1), in investigations of the cause of frothing, found that the presence of protein and protein decomposition products contribute to the stabilization and production of highly persistent froth in the presence of alkyl benzene sulfonate. It must be remembered, however, that the effect varies with the kind of detergent, as has been demonstrated by Sawyer (14) (15).

A number of effects detrimental to health, safety, and aesthetic considerations may result from the presence of frothing. Wind-blown froth can be a significant health hazard. Berg (17) has stated that bacterial counts in the foam phase have been found to be at least 20 times as great as in the liquid phase at the same relative point in the aeration tank. Froth may also be an accident hazard when it smears the tank walls and walkways with grease and sludge solids, making them exceedingly slippery. Donaldson (16) stated that in New York City

froth from final tanks or on effluents from the activated sludge plants contained 30 to 50 percent grease, and that some dried froth from tank walls contained up to 90 percent grease. Operational difficulties are imposed when heavy froth makes it impossible or hazardous to reach controls or valves. Froth is frequently blown around the plant yard and adjoining area depositing unsightly and putrefiable material. Plants in Ohio and Indiana have experienced destruction of grass, shrubs, and trees by froth deposition. At Bryan and Findlay, froth deposition has been reported to remove paint from equipment, railings, and other objects, and at Muncie, Indiana from automobiles.

Froth Control

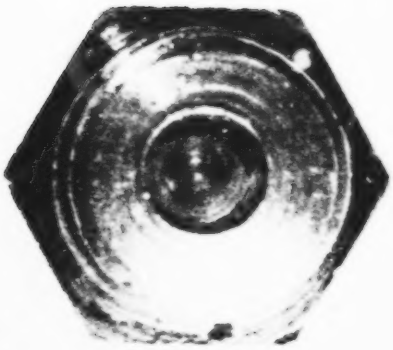
At Cranston, Rhode Island (18) frothing occurred consistently with mixed liquor solids at 1,250 parts per million, but has not occurred with solids held at 3,000 to 3,500 parts per million. Kraus (12) stated that mixed liquor solids concentration of 3,000 to 5,000 parts per million seemed best for prevention of frothing. Hoot (19) found at Philadelphia's northeast plant that mixed liquor solids in the 600 to 800 parts per million range were adequate to prevent frothing. At Columbus, frothing does not normally occur when mixed liquor solids are maintained at 2,500 parts per million or above. At Celina, there is noticeably less foam with mixed liquor solids above 2,000 parts per million but bulking sludge, according to the operator, prevents maintaining solids at that level. At Richmond, Indiana mixed liquor solids are maintained at 2,500 to 3,000 parts per million for effective control of frothing.

McNicholas (9) increased mixed liquor solids concentration from 700 to 2,450 parts per million without overcoming frothing trouble. At Benton Harbor, Michigan (6) mixed liquor solids from 1,000 to 3,500 parts per million resulted in the same degree of frothing. At Fort Wayne, frothing occurs with mixed liquor solids up to 4,000 or 5,000 parts per million. At Findlay, frothing up to 10 or 11 foot depths has occurred with mixed liquor solids of 3,000 to 4,000 parts per million. At Valpariso, Indiana frothing reportedly occurs with mixed liquor concentrations either above or below 3,500 parts per million.

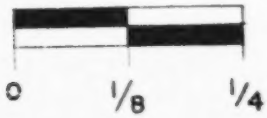
There are some objections to solids control as a means of froth prevention. Because of variations in sewage characteristics or in degree of treatment required, solids control may not be suitable for every plant. Maintaining high solids concentration increases operation costs and may not actually be possible within the limits of pumping, piping, or aeration capacity.

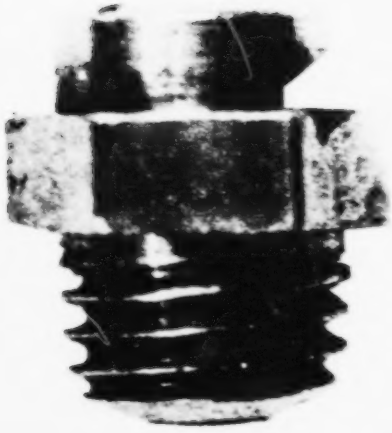
Froth on tanks and channels has been successfully controlled at a number of plants by means of water or effluent sprays. The sprays may have a conical or arc pattern, may be directed into tanks or deflected off walls, or may be applied in other manner. McNicholas (9) at Motherwell, England describes a rain-like spray of final effluent. Simpson (5) mentions the use of spray control at Mount Penn, Pennsylvania. Greeley (7) states that limited experience indicates that the efficient quantity for defrothing sprays is from 15 to 20 gallons per minute per million gallons of sewage per day, operated continuously except during

weak sewage hours, or 0.25 to over 0.50 gallons per minute per foot of aeration tank. Bargman reports (10) that at the Hyperion Plant 9,600 lineal feet of spray was installed at a cost of about $10.00 per foot. The 1,520 nozzles operate at a nozzle pressure of 25 PSI and require 4,000 gallons per minute or 0.4 gallons per minute per foot of spray. Ten gallons of chemicals per day are also sprayed. Power cost, which normally would be $.19 per million gallons, are actually $.07 per million gallons because digester gases are used for power. Experiments at Collinswood, New Jersey indicate (20) that the best system is a conical discharge high enough above the liquid to be placed on 4-foot centers. Nozzles deliver 0.5 gallons per minute of plant effluent at 15 PSI. An effective spray system has been employed by Brunner at the Fort Wayne Sewage Plant. Nozzles manufactured by the Skinner Irrigation Company were redrilled to 1/8 inch diameter and mounted on 4-foot centers along the sides of aeration tanks to spray final effluent into the tank. These nozzles deliver $1\frac{1}{2}$ gallons per minute at 25 PSI in about a 120-degree arc. One of the nozzles is shown in Figure 4. To prevent clogging, a basket screen with 1/16-inch openings is mounted ahead of the pump delivering effluent to the spray system and is cleaned once daily. A 500-gallon-per-minute pump is presently being installed to serve the 24-million-gallons-per-day secondary system, through the 1,500 lineal feet of spray lines. Operation of this system is reported to cost $.13 per million gallons of sewage treated. For emergency temporary control, garden or fire hose have been used at a number of plants.



BOTTOM VIEW





SIDE VIEW

MODIFIED SKINNER NOZZLES USED FOR FROTH CONTROL AT FORT WAYNE, INDIANA

FIG. 4

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A number of chemical defoaming agents are available and have been used successfully for foam control. They may be applied to the influent, through sprays, to return sludge, or directly to a channel or tank by simple drip type feeders, through pumps, or under pressure. Berg (17) has stated that frothing can be controlled by proper application of a reliable commercial antifoam at a cost of approximately $.50 to $1.00 per million gallons of sewage. In a later reference Berg (20) cites a cost at one plant of $.24 per million gallons based on six hours of application or six cents per million gallons based on 24 hours. He says that some plants have found as high as $.75 per million gallons justifiable, but this seems above the acceptable limit. Russell (6) reports that for the Benton Harbor Plant, with the secondary loaded at less than 4 million gallons per day, commercial defoamants would cost $10.00 per day. Estimated cost for the Findlay plant, based on continuous application, is $1.62 per million gallons. Bauer at Celina estimates, on the basis of experience, a cost of $.55 to $.65 per million gallons for one type defoamer and as much as $3.29 per million gallons for another.

Donaldson (16) reported that satisfactory control of severe frothing had been provided for a New York City plant by a permanent system of spray piping, and injection of antifoam into the spray system as needed. Neither antifoam chemical nor spray alone was satisfactory. Edwards (21) stated that the silicone antifoam agents were not satisfactory for New York City needs. Apparently none of the defoamers tried had any harmful effect on the activated sludge process, but they seemed

to lose effectiveness as they passed through the aeration tanks. There was also no effect upon purification or on settling of the mixed liquor solids. Mineral oil has been used successfully as an antifoam by McNicholas in Motherwell (18). Brunner has found at Fort Wayne, that about one gallon of number three fuel oil per 8-million-gallons-per-day aeration tank lasts about 2 hours. He also noted that the Fort Wayne Plant has not experienced frothing when receiving oily industrial wastes.

There are a number of objections to the use of chemical defoaming agents. Individual cases may differ considerably and the effectiveness of a chemical may be dependent on the particular plant and sewage involved. Some chemicals are not easily fed. Chemical foam-control tends to be expensive and cost may be an important consideration in evaluating this method.

Prevention of frothing by aeration control has been reported with some degree of success. Edwards (21) reports successful addition of settled sewage at various points along the course of flow through the tank. At the Gruppen, Germany plant (22), sewage is fed along the entire length of the aerator by means of V-notch weirs and frothing is controlled over nearly the entire tank. Step aeration is employed at Indianapolis, Indiana and frothing is less at the points of addition of fresh solids. Columbus, has had some success with the use of tapered aeration. However, sacrifice of efficient operation can result from control of aeration or by feeding sewage at late stages and consequently these methods may not find application in many cases.

A unique system has been reported at Hagen, Germany (22) where frothing is controlled in a trickling filter effluent channel by a paddle which is turned by flow and, in revolving, submerges froth in the liquid flowing in the channel.

Interference With Sewage Treatment Processes

Synthetic detergents have also been reported in a number of cases, as interfering with sedimentation and coagulation. Goldthorpe (23), Lumb (24), and Rudolfs (25) concluded from laboratory experiments with Imhoff cones that 100 parts per million total detergent has an adverse effect on sedimentation. Gaillard (26), Merrill (21), Degens (27), and others in similar studies could find no effect with concentrations up to 100 parts per million. Plant-scale studies by Hurley (28), adding 50 and 75 parts per million of total detergent (Teepol, 22 percent active sodium alkyl sulfate), indicated no influence on sedimentation. Fuhrman (29) noted a decrease in primary treatment efficiency at Washington, D.C. since the advent of detergents caused he believes, partly by detergents. Sperry (30), in a study of treatment plant operating records, showed that the great increase in the use of household detergents in 1949 and 1950 was coincident with reduction in the efficiency of primary sedimentation. Interference has been noted on a plant scale in the wool textile section of England where sulfuric acid is used to crack the grease emulsions from wool scouring. Detergents interfere with grease recovery and increase the BOD loading to the trickling filters by 30 to 50 percent (31). Examination of the mean annual suspended solids and BOD reductions

through the primary for the periods prior to and following the advent of detergents at the Bryan and Fort Wayne plants reveals no significant change in performance attributable to detergents.

The activated sludge process is apparently subject to adverse effect by synthetic detergents but there is considerable difference in their effect. Gaillard (26) stated that two detergents tested, an alkyl sulfate and a nonionic (Teepol and Lissapol N) in amounts of 100 parts per million, have no visible effect on effluent quality, although there was a slight drop in nitrate content but no apparent effect on sludge activity. One type, an alkyl aryl sulfonate (Santomerse), caused progressive deterioration in the quality of effluent and activated sludge. All protozoan organisms disappeared from the sludge. Lumb (32), in his experiments on the effects of an alkyl aryl sulfonate and a nonionic (Santomerse 1 and Lissapol N) on activated sludge, found that with 60 parts per million of these detergents the effluents became opalescent, the sludge darker in color, and the sludge protozoa fewer in number. After stopping detergent addition, the sludge that had been receiving Lissapol recovered in three weeks, but at the end of six weeks the sludge that had been receiving Santomerse did not recover and still showed a lack of active protozoa. Manganelli (33) stated that 100 parts per million of an alkyl aryl sulfonate (Nacconol NR), caused rapid deterioration of sludge and of its oxidizing ability. Low concentrations, present continuously, induced the same results. A nonionic (Tween 80), which is biologically oxidizable, had no effect. Tests showed that nitrification

was supressed within 48 hours after repeated additions of synthetic detergents in concentrations of 10 to 100 parts per million to activated sludge-sewage mixtures. Additions of the sulfonate in concentrations of 20 parts per million or more completely inhibited nitrification in five days. Degens (34) has reported that 250 parts per million total (50 parts per million active agent) of secondary alkyl sulfate in settled sewage has no effect on treatment after the activated sludge has adapted itself. Alkyl aryl sulfonate will inhibit biological treatment in concentrations of 30 parts per million total (12.5 parts per million active matter) but not at 5 parts per million active matter. Lumb (35) reports that the activated sludge process became significantly affected by concentrations of anionics above 10 parts per million.

Sawyer (14) (15) (36) found that different household detergents had varying effects on the rate of oxygen solution during diffused air aeration. Most detergents reduced the rate of oxygen transfer and, in general, those that produced little or no froth caused the greatest reduction.

For the Mogden Works (8) in Britain to do the same job as in the predetergent (pre-1950) days it was reported that the plant could handle only 80 percent of the load. The capital cost of additional plant capacity to do the former job would be over $1,600,000. Annual records of the Fort Wayne Plant, where frothing has been a problem, showed no significant decrease in over-all plant performance before or after detergents became popular. With general use of detergents, the operator

has apparently had difficulty with break down of floc causing an excess of fine solids to escape through the secondary. Suspended solids reductions in the secondary appear to bear this out.

Synthetic detergent interference with coagulation has reportedly (31) resulted in increased loading to trickling filters, which in turn has resulted in ponding. Such clogging has been substantiated as a result of laboratory experiments by Goldthorpe and Nixon at Huddersfield, England (37), using a mixture of approximately equal parts of domestic sewage and textile wastes. Hurley (38) increased the syndet (teepol) loading on his plant to 100 parts per million for 4 months with no operational difficulties and with effluents of excellent quality. Lumb (32) tested the effects of detergents (Santomerse 1, alkyl aryl sulfonate, 40 percent active and Lissapol, a nonionic, 47 percent active) on laboratory trickling filters. The settled sewage used for feed never contained more than 10 parts per million of the anionic detergent, although detergents were added at rates of 20, 30, 40, and 60 parts per million. At 30 parts per million the BOD of the effluent was slightly increased, particularly with Santomerse. No significant effects on nitrification, filter appearance, or on surface growths were evident. Sperry (30) showed that increased use of synthetic detergents corresponded with a decrease in efficiency of trickling filters in removal of suspended solids and BOD.

The literature contains little information concerning the effects of synthetic detergents on sludge digestion. If synthetic detergents

decrease sedimentation efficiency, there should be less sludge removed for digestion and, at any given plant, gas production should diminish. Sperry (30) found that increased use of household detergents caused a marked reduction in the percent of volatile matter in primary and secondary sludges, in the volume of gas produced per pound of volatile material added to the digesters, and in gas production per capita population tributary to the plant. At Batavia, Illinois (4), aeration tank frothing attributed to synthetic detergents coincided with a black, sticky, odorous digested sludge that was extremely slow in drying and very hard when dry. Degens et al. (39) studied the effects on sludge digestion of several types of syndets (a primary and a secondary sodium alkyl sulfate, an alkyl aryl sulfonate, and a nonionic typified by a polyglycol ether of an alkylated phenol). They stated that although the methane production per gram of carbon is the same for the synthetic surfactants as for soap, less of the surfactant goes into the raw sludge. There is consequently less digestible material and a resulting reduction in methane production. They also stated that concentrations of pure surfactant of less than 500 parts per million in the raw sludge did not effect methane production. However, Mangunelli (33) reported that 100 parts per million of detergent (Nacconol NR and Tween 80) slightly inhibited gas production. At the Fort Wayne plant the percent of volatile material in the raw sludge has decreased since 1945-1946. A slight decrease also apparently occurred in the volume of raw sludge but no significant decrease in gas production per unit volatile material was observed. These conditions could be related to syndet use.

Removal of Surfactants by Sewage Treatment

There are marked differences in the effects of biological oxidation processes of sewage treatment on surfactants. The alkyl sulfates appear to be quite amenable to biological treatment, but the alkyl aryl sulfonates are more resistant.

Hurley (40), reporting on plant scale experiments, stated that during the period when 75 parts per million of a secondary sodium alkyl sulfate (Teepol) was added to the sewage flow, 31 percent of the initial concentration was removed by sedimentation and 64 percent by the trickling filters and final sedimentation units. He also reported (38) that when 150 parts per million were added, no significant amount of the surfactant appeared in the final effluent and most of the surfactant was removed in the top 12 inches of the filter. Degens, Van Der Zee, and Kommer (41) stated that the alkyl sulfates were almost completely removed by biological treatment, but that a large portion of the alkyl aryl sulfonates appeared in the final effluent. Keefer (42) reported that the results of 5-day sampling at Baltimore showed 39 percent of the initial "sulfonated surface active compounds" removed by primary sedimentation and trickling filtration and 21 percent by primary sedimentation and activated sludge treatment. Lumb (32), experimenting with an alkyl aryl sulfonate (Santomerse 1) on laboratory trickling filters, stated that about 60 percent of the syndet was removed by the filter. Based on a limited number of observations of the Fort Wayne activated sludge plant, the following anionic syndet reductions (active basis) were observed (Table 2).

Table 2

Year	Number of Daily Composites	Percent Reduction
1954	8	41.0
1955	15	33.9
1956	22	26.5

Little information appears in the literature on the effect of sewage treatment processes on the nonionic detergents. Mackenzie (43) referred to Imperial Chemical Industries Technical Monograph No. 3 which states that nonionics (such as Lissapol) passed through bio-aeration processes unchanged. Manganelli (33) experimented with a nonionic (Tween 80) and found it biologically oxidizable.

Sawyer et al. (15) stated that all forms of manufactured surfactants are attacked by bacteria to some degree. Rate and extent of oxidation vary considerably depending upon the structure and size of the surfactant molecule. The alkyl aryl sulfonate and the alkyl phenoxy polyethoxy ethanol types show some utilization as bacterial food, but are so slowly stabilized that it is impossible to consider removing them in conventional activated sludge practice. The alkyl sulfates, sulfonated fatty acid esters, and certain ethylene oxide fatty acid amides and amines are subject to rapid aerobic biological stabilization.

Many important reasons exist for the removal of synthetic detergents by sewage treatment. Synthetic detergents have been

associated at Columbus, Fort Wayne, and numerous other places with unsightly frothing in receiving streams. When released to a receiving stream detergents may be passed on to water treatment works utilizing the stream as a raw water source and result in such treatment problems as frothing, interference with coagulation and softening, and serious taste complaints. In addition, toxicity to aquatic organisms, possible effect on stream reaeration, and stimulation of obnoxious algae blooms are all potential effects of synthetic detergent build up in receiving waters.

Summary

Though disagreement exists on the degree and nature of the effects of synthetic detergents on sewage treatment processes, their increased use certainly has caused and will continue to cause problems for the sewage treatment plant. Frothing which is both a hazard and a nuisance, has frequently been associated with increased detergent use. Froth control may be accomplished by plant operational methods, sprays, defoamers, or a combination of these devices. Foam control of any kind costs money and determination of the best type of control depends on the individual plant. Evidence has been presented, in spite of some disagreement in the field, to indicate that detergents do interfere with sedimentation, coagulation, trickling filters, the activated sludge process, and sludge digestion. It does appear that different detergents have different effects on the treatment processes, and that the activated sludge process is most susceptible to their interference. The most commonly used active agent, alkyl benzene sulfonate, is apparently the worst of the foamers, the most deleterious to treatment processes, and the least affected by biological treatment.

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